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PROVISIONAL SPECIFICATION

Improvements in Friction Clutches

We, JOHANN NIKOLAUS KIRP, a German citizen, of Reichskanzlerstrasse 22, Hamburg-Hochkamp, Germany, and HAROLD SINCLAIR, a British Subject, of 38, De Vere Gardens, Kensington, London, W.8, do hereby declare the nature of this invention to be as follows:—

This invention relates to rotary friction clutches of the kind in which the engaging pressure on the cooperating friction elements is generated by centrifugal force exerted by a body of liquid rotating co-axially with the clutch elements.

An object of this invention is to provide an improved clutch of this kind which is self-contained, which is not liable to overheating, and which may be arranged to disengage automatically at low speed.

A further object is to provide such a clutch having improved control means.

According to this invention, a clutch of the kind hereinbefore set forth comprises a rotary centrifugal pressure chamber for containing the body of liquid which generates the engaging pressure, a rotary reservoir chamber, a drain passage which is adapted to discharge liquid under the influence of centrifugal force from said pressure chamber to said reservoir chamber and which is preferably so positioned that liquid in draining through it is adapted to abstract heat from the cooperating friction elements of the clutch, and scooping means for returning liquid from said reservoir chamber to said pressure chamber.

A wall of the pressure chamber that is exposed to the atmosphere may be provided with internal ribs arranged to impart rotation to the liquid content and to assist in the abstraction of heat therefrom.

The said drain passage is preferably so arranged that, when the clutch is disengaged, liquid draining therethrough can flow over the working surfaces of the friction elements, the dimensions of the reservoir chamber being such that it is capable, when rotating, of withdrawing the liquid content of the clutch beyond the maximum radius of said working surfaces; so that drag is minimized or entirely eliminated.

The improved clutch preferably comprises a control spring arranged to disengage it automatically when the speed of rotation drops to a predetermined value. There may be provided a control member adapted either to interrupt the scooping action, or to disengage the clutch positively, or to perform both of these operations.

An example of the invention as applied to a multiple-plate clutch, for use for example with an internal-combustion engine, will be described.

The driving clutch part includes a pressure chamber and a reservoir chamber flanged together at their outer periphery. Both pressure and reservoir chambers are preferably of aluminium or magnesium alloy or any suitable material of high heat conductivity and may each be provided with external cooling fins for augmenting the transfer of heat from their walls to the atmosphere.

The pressure chamber is a drum of shallow section which may be fixed to the engine flywheel by means of lugs projecting from its outer surface and a boss spigotted in a locating hole in the centre of the flywheel. This boss may be used to house a ball bearing of the driven clutch shaft. The forward wall of the pressure chamber may be provided with internal ribs for assisting the setting in rotation of the fluid therein and transferring heat from the fluid to its walls and thus to the atmosphere.

The reservoir chamber is a drum of deeper section at its outer periphery than the pressure chamber, so that when rotating it can accommodate the whole or at least the greater part of the liquid from the pressure chamber in the form of a rotating fluid ring, the inner diameter of which is equal to or greater than the external diameter of the driven friction plates.

Between pressure and reservoir chamber there is clamped a ring which projects into their interior and which is provided with axial grooves on its inner periphery. This ring forms the driving carrier for the driving friction plates. These are

either curved or flat rings provided with axial splines at their outer edges which engage in the grooves of the driving carrier ring. Together with and behind this ring is also clamped between the pressure and reservoir chambers a plate which forms the driving pressure plate. This plate contains small axial drain holes at substantially the same radius as the grooves of the driving carrier ring, which lead from the pressure to the reservoir chamber.

The driven clutch part includes the driven friction plates which interlace with the driving friction plates and which are either flat or curved rings provided with axial splines at their inner edge. These engage in grooves at the outer edge of a grooved ring which forms the driven carrier. Combined with this is a plate which acts as the driven pressure plate. The driven carrier ring and the driven pressure plate are fixed in a fluid-tight manner to an annular disk which constitutes the driven disk.

Driven friction plates, driven carrier ring and driven disk together form the rear wall of the pressure chamber and thus the partition between this and the reservoir chamber.

The driven disk is fixed to a splined hub which is so mounted as to be axially slidable on a splined sleeve. The rear end of the splined sleeve carries a collar and has internal splines for accommodating the driven shaft. The forward end of the splined sleeve is attached to the inner race of the ball bearing housing in the boss of the pressure chamber. The ball bearing is preferably of the deep grooved type in order to be able to take up axial thrust. Between the rear end of the splined hub and the collar there is a helical spring which tends to force the hub against the inner race of the ball bearing and keep thus the driven friction plates out of engagement with the driving friction plates. The spring is so dimensioned that this takes place when, owing to a low speed of rotation of the driving clutch part, the centrifugal fluid pressure in the pressure chamber is insufficient to overcome the spring force. The hub of the driven disk carries a thrust ball bearing, and around this an annular conical ring is fixed to the driven disk. This ring serves as a collecting chamber for the fluid passing from the reservoir to the pressure chamber and delivers this to the latter by holes in the driven disk located near the point of attachment of the conical ring to the latter.

Transfer of the fluid from the reservoir to the collecting chamber takes place only during rotation of the driving clutch part and is effected by utilising the stored energy of the fluid ring rotating inside and together with the reservoir chamber.

The fluid transfer means are mounted on a fixed clutch part and include a radially projecting scoop tube. The outer end of this is accommdated in a circumferential groove in the periphery of the reservoir chamber. Its inner end projects into the collecting chamber at a radius substantially equal to the mean radius of the thrust ball bearing on the driven disk hub and at a distance sufficient to permit free flow from the tube between the tube end and the rear face of the ball race.

The total scoop tube area is such that during rotation of the driving clutch part the scoop tube can deliver not only more fluid to the collecting chamber and thus to the pressure chamber than flows from the pressure chamber to the reservoir chamber through the drain holes in the driving pressure plate, but also any fluid which during engagement of the clutch may escape by other means from the pressure chamber to the reservoir chamber.

The inner end of the scoop tube is carried on an internally screw threaded control sleeve which passes through a labyrinth gland in the centre of the reservoir chamber. The control sleeve engages on a fixed externally screw threaded carrier which surrounds the driven shaft. To the part of the control sleeve outside the reservoir chamber is attached a control lever. Thus when the control lever is turned, the scoop tube moves axially forward and comes in contact with the thrust ball bearing on the driven disk hub.

Turning of the control lever during rotation of the driving clutch part, therefore, first causes the flow of the fluid from the scoop tube to the collecting chamber to be interrupted and then axial displacement of the driving disk hub and thus disengagement of the clutch.

This example operates as follows:

When the clutch is engaged the control lever is always so positioned that the control sleeve is in its rearmost position. Thus fluid coming from the reservoir chamber can flow freely out of the inner end of the scoop tube into the collecting chamber and from there to the pressure chamber.

When the clutch is disengaged the control lever is always so positioned that the control sleeve is in its foremost position. Thus the flow of the fluid coming from the reservoir chamber is cut off at the inner end of the scoop tube and the driven disk is shifted axially forward.

The position of the control lever and thus of the control sleeve is immaterial only for automatic disengagement at low

revolutions of the driving clutch part owing to the centrifugal fluid pressure in the pressure chamber being less than the spring pressure.

Consequently so long as the driving clutch part is rotating, the main part of the fluid in the clutch is in the pressure chamber when the clutch is engaged and in the reservoir chamber when the clutch is disengaged.

When the clutch is engaged and during the operation of engagement, however, there is a continual flow of fluid from the outer periphery of the pressure chamber to the outer periphery of the reservoir chamber and from there through the scoop tube and the collecting chamber back to the pressure chamber. As during this flow the fluid comes in contact with the outside ribbed wall of the pressure chamber and the ribbed periphery of the reservoir chamber, it gives off its heat to these and thus to the outside air.

In the operation of disengagement there is a like fluid flow. There is none when the clutch is disengaged, as then all the fluid is in the reservoir chamber, with the exception however of automatic disengagement with the control lever in the engaging position.

When the driving clutch part is stationary all the fluid in the clutch is either wholly in the reservoir chamber or partly in this and partly in the pressure chamber. But no matter where it is, so long as the control lever is in the engaging position fluid is delivered by the scoop tube into the pressure chamber upon the driving clutch part starting to rotate with the result that the clutch begins to engage as soon as, owing to the speed of rotation, the centrifugal fluid pressure in the pressure chamber is sufficient to overcome the spring pressure.

When the driving clutch part is stationary, the clutch is always kept disengaged by the spring no matter in which position the control lever is standing.

Whilst the driving clutch part is rotating, turning the control lever so far, that the fluid flow from the scoop tube to the collecting chamber is interrupted, suffices for obtaining complete disengagement. Only when a speed of disengagement is desired which is more rapid than the peripheral flow of the fluid from the pressure to the reservoir chamber is it necessary to shift the control lever into its complete disengagement position.

One, two or a plurality of scoop tubes may be employed, or in place of scoop tubes other suitable means of transferring the fluid from the reservoir to the pressure chamber.

The friction plates may be of any suitable kind, such as for example metal to metal, or metal to composition, and may be either flat disks, curved disks, annularly ridged or grooved rings or any other type.

In place of a multi-disk clutch a single disk clutch or a cone clutch may be employed.

If it is desired to reduce the diameter of a clutch for a given duty, a plurality of pressure chambers may be arranged to operate together.

As operating fluid there may be employed a lubricating oil or a heavier liquid, for example glycerine or the liquid sold under the registered trade mark " Aroclor ".

The invention is also applicable to an automatic starting clutch for use for example with alternating-current electric motors which require to attain nearly full speed without substantial load. In this application means may be provided for delaying the scooping action automatically until the driving part of the clutch has accelerated to a predetermined speed. This result may be attained by so mounting the scoop that it is capable of pivoting eccentrically with respect to the clutch axis, and biasing it by spring means urging it in a direction opposite to that in which the clutch rotates and simultaneously towards the position in which its mouth will engage only the innermost layer of the liquid ring in the reservoir chamber. The strength of the biasing means is such that, at the predetermined speed, the pressure due to the scooping action displaces the scoop against a stop which holds it with its mouth in the radially outermost position. Alternatively the scoop may be mounted concentrically with the clutch or be fixed, and the scoop delivery duct may contain a spring-loaded valve arranged to open only when the fluid pressure generated by the scoop rises to a particular value. The centrifugal pressure chamber may have a longer axial dimension at its periphery than near its middle, so as to cause a relatively slow initial increase in the radial thickness of the liquid ring formed therein by the scoop.

Dated this 16th day of November, 1938.
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COMPLETE SPECIFICATION

Improvements in Friction Clutches

We, JOHANN NIKOLAUS KIEP, a German citizen, of Reichskanzlerstrasse 22, Hamburg-Hochkamp, Germany, and HAROLD SINCLAIR, a British Subject, of 38, De Vere Gardens, Kensington, London, W.8, England, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to rotary friction clutches of the kind in which the engaging pressure on the cooperating friction elements is generated by centrifugal force exerted by a body of liquid rotating coaxially with the clutch elements.

An object of this invention is to provide a clutch of this kind which is self-contained, and which is provided with improved control means which eliminate risk of excessive slip to which centrifugal clutches are usually liable at their engaging speeds.

A further object is to provide such a centrifugal clutch which normally operates automatically, but which, if desired, can also be actuated by a supplementary control which over-rides the automatic control.

Another object is to make provision in such a clutch for dissipating by means of the actuating liquid the heat generated at the friction surfaces.

Another object is to provide such a centrifugal clutch which is completely disengaged until its driving element attains nearly its maximum speed, whereupon the clutch engages progressively up to the fully engaged condition, this arrangement being especially suitable for use as an automatic starting clutch for electric motors, particularly single-phase machines which have a weak starting torque.

According to this invention in one aspect, a clutch of the kind hereinbefore set forth comprises a rotary centrifugal pressure chamber for containing the body of liquid which generates the engaging pressure, a rotary reservoir chamber, at least the peripheral portion of the boundary of which is drivably connected with the driving element of the clutch, a drain passage which is adapted to discharge liquid under the influence of centrifugal force from said pressure chamber to said reservoir chamber, and scooping means for returning liquid from said reservoir chamber to said pressure chamber.

According to this invention in another aspect, a clutch of the kind hereinbefore set forth comprises a rotary driving element, a rotary driven element, co-operating friction surfaces on said elements, a rotary centrifugal pressure chamber having a boundary portion capable of displacement under the influence of centrifugal force acting on liquid contained therein to effect engagement of said friction surfaces together, a reservoir chamber, at least the peripheral portion of the boundaries of said chambers being arranged to rotate with said driving element, means for discharging liquid from said pressure chamber to said reservoir chamber, and means adapted to operate in response to rotation of said driving element for transferring liquid from said reservoir chamber to said pressure chamber.

According to this invention in a further aspect, a clutch of the kind hereinbefore set forth comprises a rotary driving element, a rotary driven element, a pressure chamber, a reservoir chamber having a diameter exceeding that of said pressure chamber, at least the peripheral portions of the boundaries of said chambers being constrained to rotate with said driving element and said pressure chamber having a boundary portion capable of displacement under the influence of centrifugal force acting on liquid contained therein for the purpose of frictionally engaging said driving and driven elements together, a drain port for discharging liquid under the influence of centrifugal force from said pressure chamber to said reservoir chamber, and liquid-transfer means in said reservoir chamber which are responsive to the speed of rotation of said driving element and which serve to deliver liquid to said pressure chamber, at a rate exceeding the rate of drainage to said reservoir chamber, only when the speed of said driving element exceeds a predetermined value.

Fig. 1 is a diagramatic sectional side elevation of the upper half of a clutch suitable for automotive vehicles.

Fig. 2 is a sectional side elevation of a starting clutch for an electric motor, taken on the line 2—2 in Fig. 3.

Fig. 3 is a section taken approximately on the line 3—3 in Fig. 2.

Fig. 4 is a section of a detail, taken on the line 4—4 in Fig. 2, and

Fig. 5 is a diagrammatic sectional side elevation of part of another example of starting clutch.

In the example shown in Fig. 1 the driving clutch part includes a pressure chamber 10 and a reservoir chamber 11 contained within drums 12 and 13 which are flanged together at their outer periphery. Both drums 12 and 13 are preferably of aluminium or magnesium alloy or any suitable material of high heat conductivity and may each be provided with external cooling fins 14 and 15 for augmenting the transfer of heat from their walls to the atmosphere. The pressure chamber drum 12 is fixed to an engine flywheel 16 by means of screws engaging in lugs 17 projecting from its outer surface and a boss 18 spigoted in a locating hole 19 in the centre of the flywheel 16. The boss 18 houses a ball bearing 20 indirectly supporting the driven clutch shaft 21. The forward wall of the drum 12 may be provided with internal ribs 22 for assisting the setting in rotation of the liquid therein and the transfer of heat from the liquid to its walls and thus to the atmosphere.

The reservoir chamber 11 is of deeper section at its outer periphery than the pressure chamber drum, so that when rotating it can accommodate the whole or at least the greater part of the liquid from the pressure chamber in the form of a rotating ring, the inner diameter of which is equal to or greater than the external diameter of the driven friction plates. Between the drums 12 and 13 is clamped a ring 23 which projects into their interior and which is provided with axial grooves 24 in its inner periphery. This ring forms the driving carrier for the friction plates 25 which are flat rings provided with axial splines at their outer edges which engage in the grooves 24. Together with and behind the ring 23 is also clamped between the drums 12 and 13 a driving abutment plate 26, provided with small axial drain holes 27 disposed at substantially the same radius as the grooves 24 of the driving carrier ring and leading from the pressure chamber 10 to the reservoir chamber 11.

The driven clutch part includes driven friction plates 28 which interlace with the driving plates 25 and which are flat rings provided with axial splines at their inner edge. These engage in grooves 29 formed in the outer edge of a grooved ring 20 which forms the driven carrier and which is rigid with a driven pressure plate 31. The parts 30 and 31 are fixed in a fluid-tight manner to an annular driven disk 22. The driven friction plates 28 and 31, the driven carrier ring 30 and the driven disk 32 together form the rear wall of the pressure chamber 10 and thus the partition between this and the reservoir chamber 11.

The driven disk 32 is fixed to a hub 33 which is splined to and axially slidable on a sleeve 34. The rear end of the sleeve 34 has an intergral collar 35 and is splined to the driven shaft 21. The forward end of the sleeve 34 is attached to the inner race of the ball bearing 20, which is preferably of the deep-grooved type in order to be able to take up axial thrust. Between the rear end of the hub 33 and the collar 35 there is a helical spring 36 which tends to force the hub 33 against a ring 37 clamped with the inner race of the ball bearing 20 and to keep the clutch disengaged. The spring 36 is so dimensioned that disengagement takes place, when, owing to a low speed of rotation of the driving clutch part, the centrifugal liquid pressure in the pressure chamber 10 is insufficient to overcome the spring force. The hub 33 carries a thrust ball bearing 38, and around this an annular conical ring 39 is fixed to the driven disk 32. This ring serves as a collecting chamber for the liquid passing from the reservoir to the pressure chamber and delivers this to the latter by holes such as 40 in the driven disk.

Transfer of the liquid from the reservoir to the collecting chamber takes place when the driving clutch part is rotating and is effected by utilising the stored energy of the liquid ring rotating inside and together with the reservoir chamber. The liquid transfer means are mounted on a fixed clutch part and include one or more radially projecting scoop tubes such as 41. The mouth of the scoop tube is accommodated in a circumferential groove 42 in the periphery of the reservoir drum. Its inner end projects into the collecting cone 39 at a radius substantially equal to the mean radius of the thrust ball bearing 38 and at a distance sufficient to permit free flow from the tube between the tube end and the rear face of the ball race.

The total scoop tube area is such that, when the driving clutch part is rotating, the scoop tube can deliver not only more liquid to the collecting cone and thus to the pressure chamber 10 than flows from this chamber to the reservoir chamber 11 through the drain holes 27, but also any liquid which during engagement of the clutch may escape by other means from the pressure chamber to the reservoir chamber.

The inner end of the scoop tube is fixed to an internally screw-threaded control sleeve 43 which passes through a labyrinth gland 44 in the centre of the drum 13. The control sleeve is engaged on a fixed externally screw-threaded carrier 45 and is provided with a control lever 46. When

the control sleeve is suitably turned by the lever 46 the scoop tube 41 is moved axially forward and its flattened discharge end comes in contact with and is closed by the ball bearing 38. Where only one scoop tube is provided, the control sleeve may be provided with a projection on the opposite side to the scoop tube, which is likewise adapted to engage the ball bearing. Such turning of the control sleeve while the driving clutch part is rotating, therefore, first causes the flow of liquid from the scoop tube to the collecting chamber to be interrupted and then axial displacement of the driven disk hub 33 and thus disengagement of the clutch.

This example operates as follows.

When the control lever 46 is in the position shown in Fig. 1, the sleeve 43 being in its rearmost position, and when the engine is running, the scoop tube 41 picks up liquid from the reservoir chamber 11 and discharges it within the cone 39, whence it passes through the holes 44 into the pressure chamber 10. Since the flow of liquid delivered by the scoop exceeds the discharge through the drain holes 27, the pressure chamber 10 fills with liquid which, under the influence of centrifugal force, urges the disk 32 to the rear. Thus, when the engine speed is high enough, the pressure due to the liquid overcomes the force exerted by the disengaging spring 36 and engages the clutch automatically. When the engine speed falls below a critical value, the pressure due to the liquid becomes less than the spring pressure and the clutch disengages automatically. When the control lever is so set that the clutch operates automatically, there is a continuous flow of liquid from the reservoir chamber through the scoop to the pressure chamber, and thence past the friction plates and through the drain holes 27 back to the reservoir chamber, the liquid passing through the clearance between the splines on the plates 25 and the grooves 24 when the clutch is engaged. Since the circulating liquid flows over the ribbed walls of the drums 12 and 13, it gives off to these parts the heat generated at the friction surfaces.

The clutch can be disengaged, when the engine speed is high, by actuating the control lever 46 so as to displace the control sleeve 43 axially forwards, until the discharge end of the scoop tube 41 engages the ball bearing 38, which interrupts the flow of liquid to the pressure chamber. If it is desired to disengage the clutch more quickly than it would disengage in consequence of the escape of liquid through the drain holes 27, the control lever 46 can be actuated further so as to cause the discharge end of the scoop tube to displace the driven hub 33 axially forwards against the force of the liquid in the pressure chamber.

As operating liquid there may be employed a lubricating oil, or a heavier liquid, for example glycerine, or the liquid sold under the Registered Trade Mark "Aroclor".

Figs. 2 and 3 show an automatic starting clutch for use for example with alternating-current electric motors of the kind which requires to attain nearly full speed before any substantial load is applied. In this example the scooping action is automatically delayed until the driving part of the clutch has accelerated to a predetermined speed.

On the motor shaft 50 is fixed a cast-iron hub 52 which is forced on the shaft and constrained to rotate therewith by a key 51. A pulley 53 is journalled on the hub 52 by bushes 54. In the boss 55 of the pulley are fixed a plurality of driving pins, such as 56, on which is slidably fitted a driven friction plate 57. The hub 52 is provided with a driving flange 58 having at its periphery a cylindrical flange 59. An annular driving plate 60 is fixed against the rim 59 by screws such as 61 engaging in a cast-iron reservoir rim 62. The rim 59 is gapped in way of the screws 61, as at 63, and the gaps 63 accommodate radially slotted projections 64 on a presser plate 65, the projections 64 embracing the screws 61. Helical springs 66 mounted on the screws 61 are compressed between the plate 60 and 65 and tend to keep the clutch disengaged.

The pressure chamber comprises an annular flexible bag 67, made for example of rubberized fabric (such as is employed for landing brakes of aircraft) and accommodated between the driving flange 58 and the presser plate 65, a shield ring 68 of heat-insulating material being interposed between the bag 67 and the plate 65. One or more screw-threaded nipples such as 69, pass through the flange 58 and are secured in a fluid-tight manner in apertures in the bag 67 by means of nuts 70. An annular collector plate 71 is fixed close to the flange 58 by the screws 61 and by rivets such as 72, the inner edge of this plate being coned to form a collector channel 73. The plate 71 is provided with a suitable number of radial indentations, such as 74, which communicate between the channel 73 and the nipples 69 and which form a portion of the pressure chamber. A small drain hole 75 is formed in the plate 71 at the outer end of each indentation 74, and the effective area of this drain can be regulated by a needle 75A extending from an adjusting screw 75B which is engaged in a reservoir end

wall 84 and locked by a nut 75C. There may be provided a larger hole 76 at any desired position along the indentation 74, which position determines the centrifugal head of the liquid in the pressure chamber.

A shaft extension 77 is screwed to the end of the hub 52 at 78 and forms a bearing for a cast-iron scoop housing 79 which is provided with an oil-less bush and which is prevented from rotating by a link 80 attached at 81 to the motor bed plate. The housing 79 is located axially by a washer 82 retained by a lubricating nipple 83. The reservoir end wall 84 is secured by screws, such as 84A to the ring 62 and is sealed with respect to the housing 79 by a labyrinth gland including an annular disk 85 fixed to the housing and accommodated within a tubular baffle 86 fixed to the inner side of the wall 84. The tubular baffle is extended by a dished cap 86A fixed on the outer side of the wall 84, which is perforated by drain holes, such as 87 adjacent to the tubular baffle.

A scoop-tube boss 88 is accommodated in a transverse channel 89 (Fig. 4) formed in the housing 79 and is fixed to a control pin 90 journalled in the housing and in turn fixed to a control lever 91. The scoop tube 92 communicates through the hollow boss 88 with a port 93 in the front of the housing 79 and leading to the collector channel 73. The mouth 94 of the scoop tube is adapted to lie in a circumferential channel 95 in the interior of the reservoir ring 62. The scoop tube is provided with a drag lug 96 which is also adapted to lie in the channel 95. The scoop-tube boss 88 is provided with a stop arm 97 (Fig. 4) on which is mounted a cushioning member, for example a rubber ring 98, adapted to engage an abutment surface 89A on the base of the channel 89, as the mouth of the scoop tube attains its radially outermost position shown in full lines in Fig. 3 (hereinafter termed the "operative position") when being displaced in the same direction as the direction of rotation of the ring 62. One end of a tension control spring 99 is pivotally connected to an anchorage lug 100 mounted on the housing 79. The spring 99 urges the scoop tube towards the radially innermost position shown in dotted lines in Fig. 3 (hereinafter termed the "inoperative position"); and a lug 101 on the boss 88 by abutting against the base of the channel 89 prevents the scoop tube from moving further radially inwards.

The lubricator 83 serves to lubricate the pulley bushes 54, and any lubricant which exudes from the bush nearer the flange 58 escapes from the clutch through a radial channel 65A formed in the flange 65. A circumferential channel 65C traps any lubricant that may approach the friction face of the plate 65 and delivers it through a port 65B to the channel 65A.

This example, which, with a pulley diameter of 10 inches, is suitable for transmitting 25 horse-power at 1450 r.p.m., operates as follows.

When the clutch is assembled, about 1½ lb. of mercury is placed in the reservoir chamber to serve as working liquid. When the motor is started (the direction of rotation being shown by the arrow in Fig. 3), the mercury forms a ring in the channel 95, its inner surface being denoted by 102 in Fig. 3. At first the scoop tube is held by the spring 99 in its inoperative position with its mouth clear of the liquid and the drag lug 96 dipping into the liquid. Under these conditions the control arm 91 lies at a substantial angle to the axis of the control spring 99, so that the control torque resisting displacement of the scoop tube has a relatively high value.

When the motor speed attains a suitable value, for example between 90 and 95 percent. of the synchronous speed, the torque imposed on the scoop tube by the drag of the liquid on the lug 96 exceeds the control torque due to the spring 99, with the result that the scoop tube is displaced to is operative position, its mouth becoming immersed in the liquid. The control arm 91 now lies at a considerably reduced angle to the axis of the spring 99, with the result that the control torque imposed by this spring is reduced to a relatively low value and risk of "hunting" of the scoop tube is thereby eliminated. As the scoop tube attains its operative position, the buffer ring 98 engages the abutment 89A, cushioning the shock due to the arresting of the scoop tube and thereby avoiding risk of its bending or fracture.

The liquid picked up by the scoop tube passes through the port 93 to the collector channel 73 and thence to the pressure chamber comprising the indentations 74 and the bag 67. The effect of centrifugal force on the liquid expands the bag 67, forcing the presser plate 65 towards the plate 60 and thereby fully engaging the clutch. Thereafter a restricted leakage of liquid from the pressure chamber to the reservoir chamber occurs through the holes 75, and the remainder of the flow through the scoop escapes through the holes 76; the liquid level in the reservoir chamber under these conditions, which is denoted by 103, is such that the mouth 94 of the scoop tube is immersed deeply enough to retain the scoop tube in its operative position.

When the motor has been switched off

and its speed falls to a predetermined value lower than that at which the clutch engaged, the torque due to the force of the liquid impinging on the mouth 94 becomes less than the control torque due to the spring 99 and the scoop tube returns to its inoperative position, as shown by dotted lines in Fig. 3. The liquid in the pressure chamber escapes through the holes 75, allowing the bag 67 to be collapsed by the pressure of the clutch disengaging springs 66.

This clutch has the following advantages. It enables the motor to run up almost to its full speed without any load, whereupon the scoop tube is moved with a snap action to its operative position. The full engaging force on the friction surfaces is now built up at any desired rate, determined by the ratio of the flow capacity of the scoop tube to that of the escape holes. As soon as the circulation conditions reach equilibrium, the clutch is in condition to transmit its full working torque. Consequently the slipping that occurs is no more than is necessary to enable the load to be smoothly accelerated. Similarly, when the motor is switched off, the clutch rapidly and completely disengages, the period of slipping being negligibly short.

The example shown diagrammatically in Fig. 5 is an "Aroclor"-actuated cone clutch, also suitable for use as an automatic starting clutch for an electric motor. A driving flange 110 is fixed to the motor shaft 111. A clutch driving conical ring 112 is fixed to the flange 110 by screws such as 113 engaging in a ring 114. A clutch driven conical member 117 is rigid with a hub 118 of a pulley 119, this hub being rotatable and slidable on the shaft 111. Springs such as 120 are compressed between the hub 118 and a thrust collar 121 journalled on the shaft 111 and these springs bias the clutch towards its disengaged condition. A dished and apertured casing 122 secured by the screws 113 encloses the clutch, being sealed with respect to the hub 118 by a labyrinth gland including a built-up tube 123A, 123B having an internal flange 124 provided with drain ports such as 125 near its periphery. The hub 118 is provided with a liquid thrower ring 126 positioned to discharge into the space between the casing 122 and the flange 124. Drain ports such as 127 pass through the flange 110 and the ring 112 from the outermost part of the space contained by the casing 122, and a restricted drain hole 128 passes through the flange 110 adjacent to the friction surface of the ring 112.

A boss 129 is journalled on an extension 111A of the motor shaft and is fixed to a bracket 130 which prevents it from rotating. A scoop tube 131 is fixed to the boss 129 and communicates through an automatic valve with a port 132 formed in the inner end of the boss 129 and opening within a collector cone 133 fixed to the flange 110. Ports 134 lead from the interior of this cone to the pressure chamber 135 formed between the flange 110 and the clutch driven member 117. The automatic valve includes a ball 136 accommodated in a cylindrical bore 137 and urged against a seating 138 by a wedge 139 which is biased by an adjustable compression spring 140. The shell 115 is sealed with respect to the boss 129 by a labyrinth gland including a flange 145 fixed to the boss 129 and a built-up tubular portion 141, 142 containing an internal flange 143 having drain ports such as 144 through its outer margin.

This clutch operates as follows, it being assumed that working liquid has been inserted into the reservoir chamber 116 through a filling plug (not shown).

When the motor is started, the springs 120 at first keep the clutch disengaged, and the liquid forms in the reservoir chamber a ring into which the scoop tube dips. The valve ball 136 is at first kept on its seat 138 by the wedge 139, so that no liquid is discharged by the scoop tube. When, however, the motor speed attains a suitable high value, the fluid pressure in the scoop tube acting on the area of the ball 136 exposed through the seating 138 exerts a force sufficient to lift the ball off this seating against the biasing force exerted by spring 140 on the wedge 139 and against the friction between the wedge and the parts against which it slides. Liquid is thereupon discharged through the narrow clearance space between the ball and the bore 137 and thence through the port 132 to the cone 133. The valve is so proportioned that it has a "pop" action—that is to say, the said clearance space is so restricted that, after the ball has been moved from its seating, the fluid pressure, which now acts on the whole projected area of the ball, exerts on it a force substantially exceeding the force exerted by the spring 140 which tends to return it to its seating and which is reduced by the effect of the friction acting between the wedge and the parts along which it slides. There is therefore no risk of "hunting" of the valve.

Liquid discharged by the scoop tube into the cone 133 passes through the ports 134 into the pressure chamber 135 faster than liquid can escape from the pressure chamber between the friction surfaces of the clutch parts 112 and 117 and through the drain hole 130

128. Consequently the pressure chamber fills with liquid, the centrifugal force on which causes a fluid pressure which displaces the clutch driven parts 117, 118 and 119 against the action of springs 120 into a position such that the friction surfaces of the clutch are engaged together. The clutch is thus fully engaged without any unnecessary slipping. When the motor has been switched off, as soon as its speed falls to a predetermined value, the spring 140 closes the ball valve and interrupts the delivery of liquid by the scoop tube to the pressure chamber, which thereupon empties through the drain hole 128 to the reservoir chamber, so that the clutch rapidly disengages under the influence of the springs 120.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A clutch of the kind hereinbefore set forth, comprising a rotary centrifugal pressure chamber for containing the body of liquid which generates the engaging pressure, a rotary reservoir chamber, at least the peripheral portion of the boundary of which is drivably connected with the driving element of the clutch, a drain passage which is adapted to discharge liquid under the influence of centrifugal force from said pressure chamber to said reservoir chamber, and scooping means for returning liquid from said reservoir chamber to said pressure chamber.

2. A clutch of the kind hereinbefore set forth, comprising a rotary driving element, a rotary driven element, cooperating friction surfaces on said elements, a rotary centrifugal pressure chamber having a boundary portion capable of displacement under the influence of centrifugal force acting on liquid contained therein to effect engagement of said friction surfaces together, a reservoir chamber, at least the peripheral portions of the boundaries of said chambers being arranged to rotate with said driving element, means for discharging liquid from said pressure chamber to said reservoir chamber, and means adapted to operate in response to rotation of said driving element for transferring liquid from said reservoir chamber to said pressure chamber.

3. A clutch of the kind hereinbefore set forth, comprising a rotary driving element, a rotary driven element, a pressure chamber, a reservoir chamber having a diameter exceeding that of said pressure chamber, at least the peripheral portions of the boundaries of said chambers being constrained to rotate with said driving element and said pressure chamber having a boundary portion capable of displacement under the influence of centrifugal force acting on liquid contained therein for the purpose of frictionally engaging said driving and driven elements together, a drain port for discharging liquid under the influence of centrifugal force from said pressure chamber to said reservoir chamber, and liquid-transfer means in said reservoir chamber which are responsive to the speed of rotation of said driving element and which serve to deliver liquid to said pressure chamber, at a rate exceeding the rate of drainage to said reservoir chamber, only when the speed of said driving element exceeds a predetermined value.

4. A clutch as claimed in claim 1, 2 or 3, wherein the whole of the boundary of said pressure chamber rotates with said driving element.

5. A clutch as claimed in claim 1, 2 or 3, wherein a part only of the boundary of said pressure chamber rotates with said driving element and is adapted to impart to liquid in said pressure chamber a substantial rotation when said driving element is rotating and said driven element is at rest.

6. A clutch as claimed in claim 4 or 5, and comprising scooping means in said reservoir chamber for engaging liquid therein and transferring it to said pressure chamber, wherein said scooping means are capable of being rendered operative and inoperative.

7. A clutch as claimed in claim 6, and comprising a control member initially operable for interrupting the transfer of liquid by said scooping means to said pressure chamber and further operable for disengaging said clutch mechanically.

8. A clutch as claimed in any of claims 4 to 7, wherein liquid in discharging from said pressure chamber to said reservoir chamber can flow across the cooperating friction surfaces of the clutch.

9. A clutch as claimed in claims 1, 2, 3 or 4 and 6, and comprising a non-rotatable support in said reservoir chamber, a scoop tube in said reservoir chamber and journalled on said support about an axis parallel to the axis of rotation of said reservoir chamber so as to be displaceable between an operative position in which the lip of the scoop tube is adjacent the periphery of said reservoir chamber and an inoperative position in which said lip is more remote from said periphery and only a relatively small part of said scoop tube is adapted to engage the ring of liquid present in said reservoir chamber when the clutch is fully disengaged, automatic control means biasing said scoop tube

from said operative to said inoperative position in such a sense that its lip will move oppositely to the normal direction of rotation of the adjacent portion of said reservoir chamber, and a cushioned stop positioned to arrest said scoop tube as it attains said operative position.

10. A clutch as claimed in claim 9, wherein said automatic control means bias said scoop tube in such a manner that the torque imposed on said scoop tube by the liquid to displace it from its inoperative position is higher than the torque required to be imposed on it by the liquid to retain it in its operative position.

11. A clutch as claimed in claims 4 and 6, 9 or 10, wherein said pressure chamber includes a resilient annular bag and a duct disposed at least in part radially outwards and leading from said reservoir chamber to said bag.

12. A clutch as claimed in claim 11, and comprising on the rotary driving element, on which the driven element has a bearing, an abutment and a presser element constrained to rotate with but axially slidable relatively to said abutment, said resilient annular bag being disposed between said abutment and said presser element, means for supplying lubricant to said bearing, a shield interposed between said bag and said presser element and positioned to prevent excess lubricant that exudes from said bearing from reaching said bag, and a duct formed at least in part radially in said driving element to discharge such excess lubricant.

13. A clutch as claimed in claim 1, 2, 3, 4, 6, 9, 10, 11 or 12, and comprising a drain passage the effective area of which is adapted to be adjusted and which is disposed in the neighbourhood of the periphery of said pressure chamber for discharging liquid under the influence of centrifugal force to said reservoir chamber.

14. A clutch as claimed in claim 1, 2, 3, 4, 6, 9, 10, 11, 12, or 13, and comprising a drain passage debouching from the neighbourhood of the periphery of said pressure chamber, an inlet disposed in the neighbourhood of the radially inner part of said pressure chamber for admitting liquid thereto, and a port debouching from the radially intermediate part of said pressure chamber for discharging excess liquid to said reservoir chamber.

15. A clutch as claimed in claim 1, 2, 3, 5, 6 or 8, and comprising a scoop tube in said reservoir chamber and held by a non-rotatable support for engaging liquid therein during rotation of the driving element of the clutch, said scoop tube communicating with said pressure chamber through a loaded valve set to open under the influence of the fluid pressure due to the scooping action when the speed of said reservoir chamber rises to a predetermined value.

16. A clutch as claimed in claim 15, wherein said valve is a spring-loaded valve having a "pop" characteristic such that it will open under the influence of the fluid pressure due to the scooping action at a particular speed of rotation of said reservoir chamber when the liquid content of said reservoir chamber is the maximum, and will close only when the fluid pressure has dropped to a value lower than that existing at the same speed of rotation when the liquid content of said reservoir chamber is the minimum.

17. The improved centrifugal clutches constructed and operating substantially as herein described and as shown in the accompanying drawings.

Dated this 2nd day of November, 1939.

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[This Drawing is a reproduction of the Original on a reduced scale.]

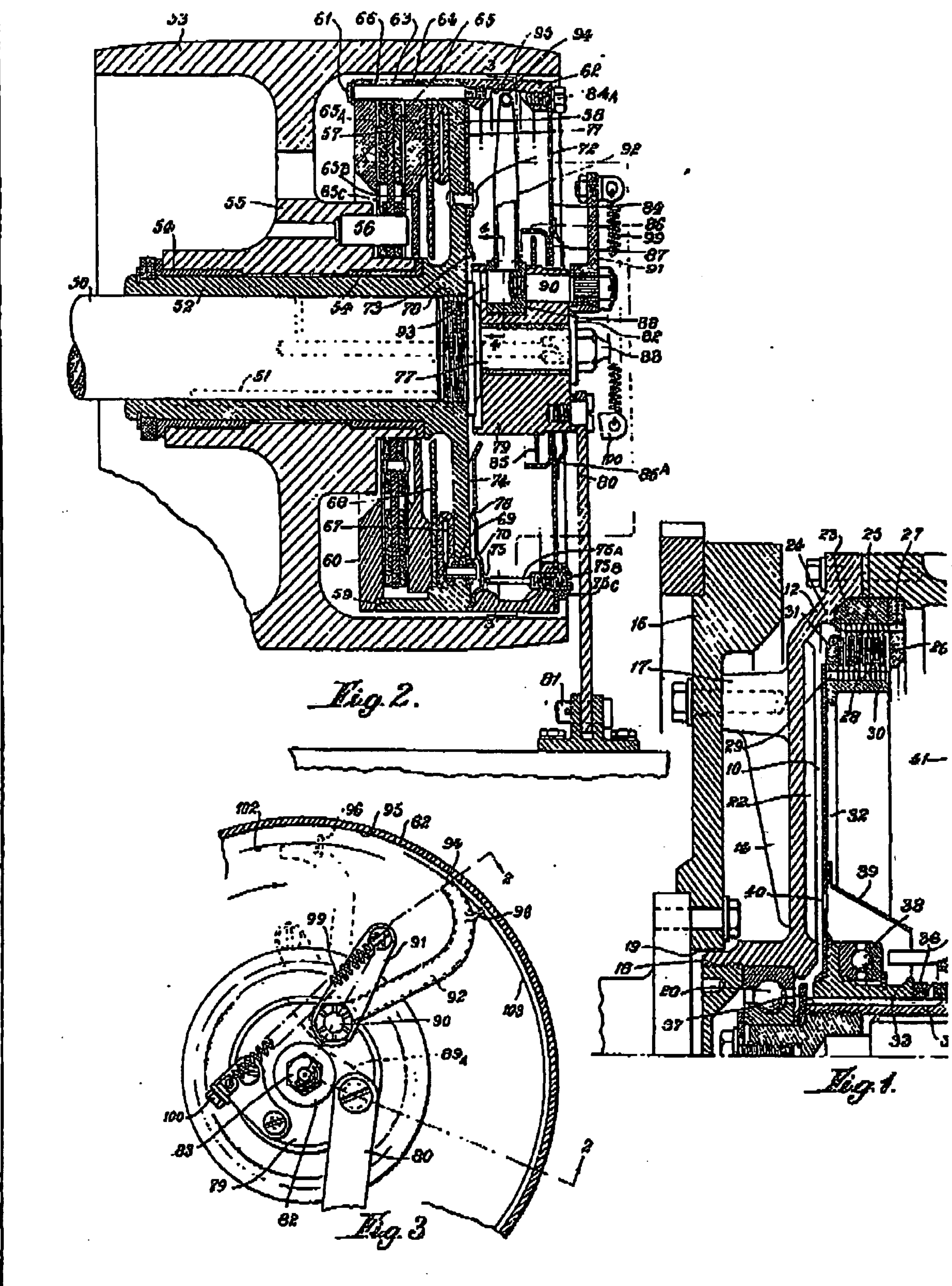


Fig. 2.

Fig. 3

Fig. 1.

1 SHEET

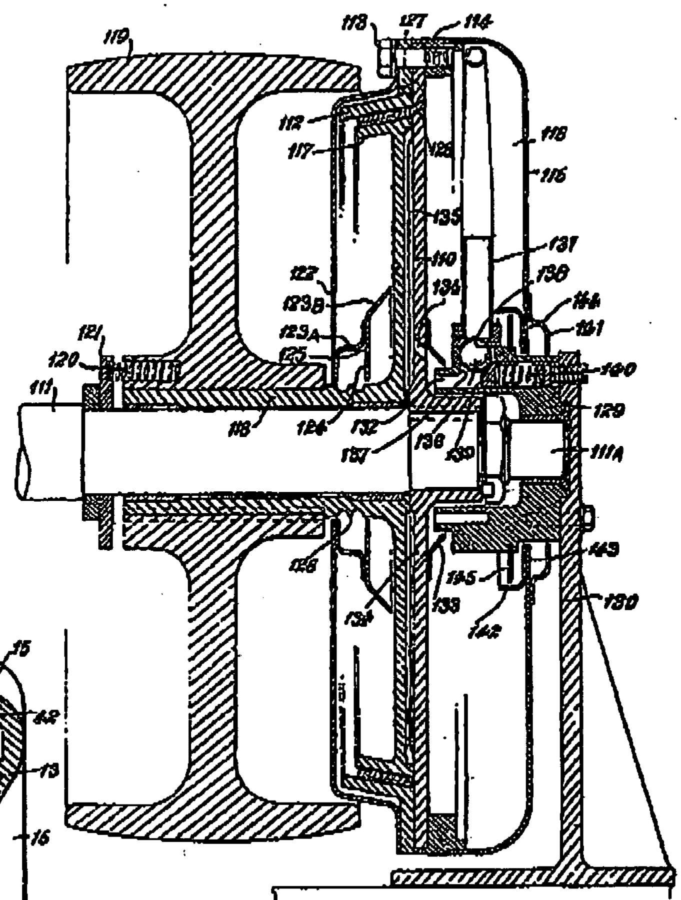


Fig. 5.

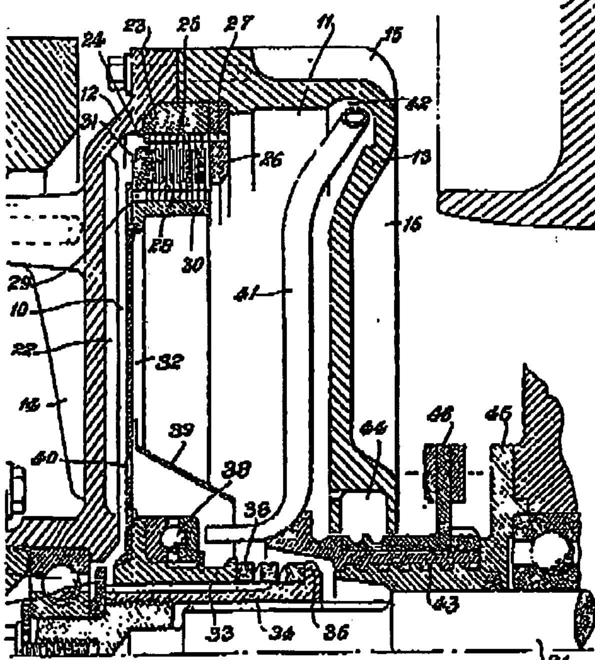


Fig. 1.

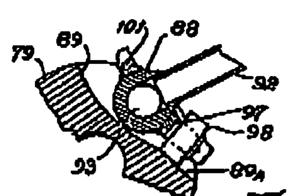
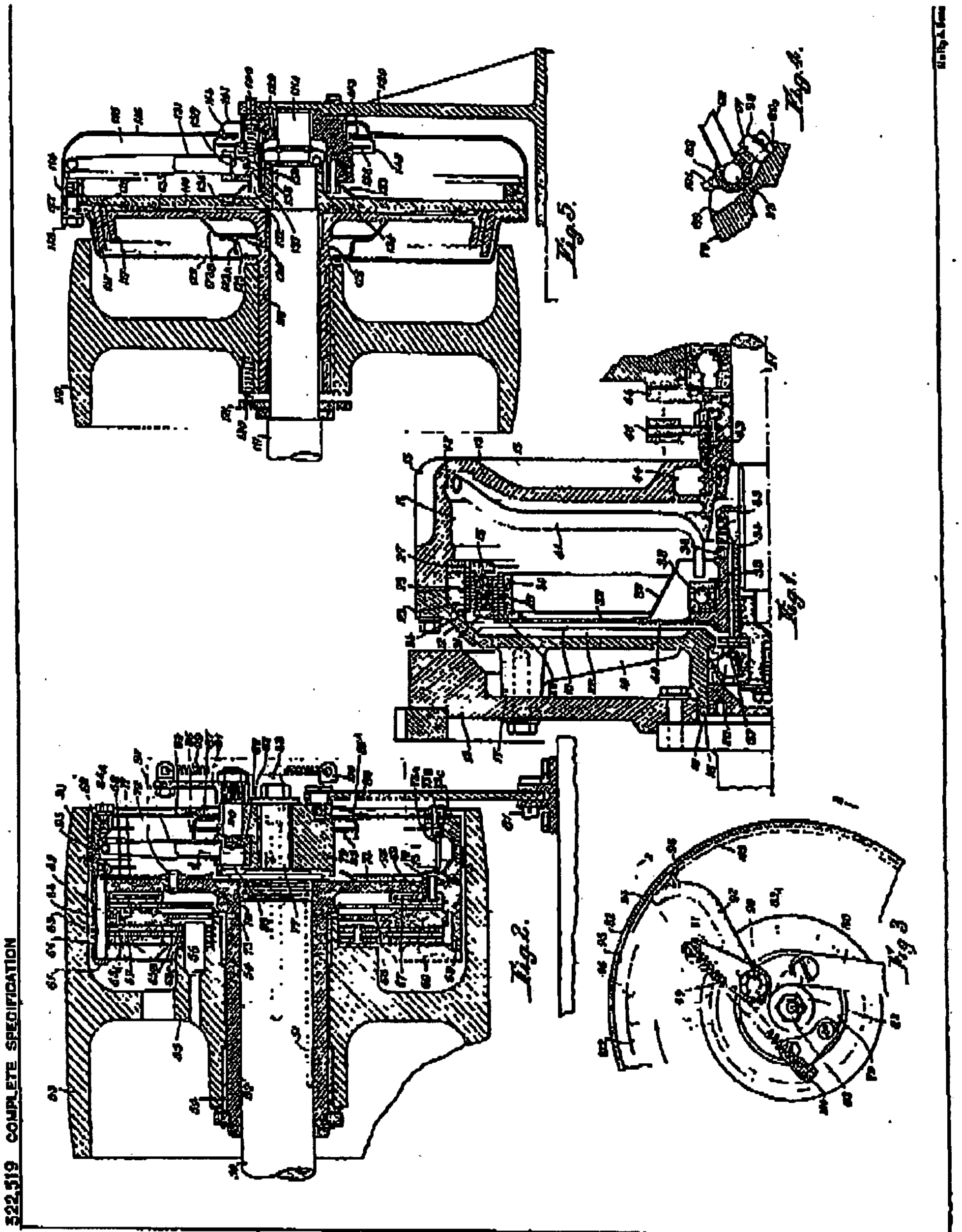


Fig. 4.



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